CLAIMS

What is claimed is:

1. A method for treating a high dielectric layer of a semiconductor device, comprising:

nitriding a high dielectric layer on a silicon substrate, wherein said high dielectric layer comprises a nano laminate comprising a Group 3 metal oxide layer and a layer selected from the group consisting of a hafnium oxide layer and a zirconium oxide layer and wherein an ozone oxide layer is positioned between said high dielectric layer and said silicon substrate; and

post treating the high dielectric layer, ozone oxide layer, and silicon substrate.

2. The method of claim 1, wherein nitriding a high dielectric layer comprises nitriding said high dielectric layer using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment process in a nitrogen atmosphere, and a thermal treatment process comprising thermally treating the high dielectric layer after forming a nitrogen layer on the high dielectric layer.

3. The method of claim 1, wherein post treating the high dielectric layer, ozone oxide layer, and silicon substrate comprises post treating using a process selected from the group consisting of an oxidation process and an annealing process.

4. The method of claim 1, further comprising forming said high dielectric layer on an ozone oxide layer over a silicon substrate.

5. The method of claim 4, wherein forming said high dielectric layer on an ozone oxide layer over a silicon substrate comprises:

depositing a first layer selected from the group consisting of a hafnium oxide layer and a zirconium oxide layer on the ozone oxide layer; and

depositing a Group 3 metal oxide layer over the first layer.

6. The method of claim 5, wherein the Group 3 metal oxide layer is selected from the group consisting of aluminum oxide and yttrium oxide.

7. The method of claim 5, further comprising depositing an additional layer over the ozone oxide layer, the additional layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

8. The method of claim 4, further comprising forming an ozone oxide layer on a silicon substrate.

9. The method of claim 8, wherein forming said ozone oxide layer on a silicon substrate comprises flushing said silicon substrate with ozone *in situ*.

10. The method of claim 8, wherein forming said ozone oxide layer on a silicon substrate comprises forming said ozone oxide layer using atom layer deposition.

11. The method of claim 8, wherein forming said ozone oxide layer on a silicon substrate comprises forming said ozone oxide layer using chemical vapor deposition.

12. The method of claim 8, wherein forming said ozone oxide layer on a silicon substrate comprises forming said ozone oxide layer at a temperature between about 320 °C and about 450 °C.

13. The method of claim 1, wherein said ozone oxide layer comprises an ozone oxide layer having a thickness of about 8 Å or less.

14. A method for treating a high dielectric layer of a semiconductor device, comprising:

nitriding a silicon substrate and a high dielectric layer formed on an ozone oxide layer over said silicon substrate, said high dielectric layer comprising at least one layer selected from

the group consisting of a hafnium oxide layer, a zirconium oxide layer, and a Group 3 metal oxide layer; and

then annealing the silicon substrate, ozone oxide layer, and high dielectric layer.

15. The method of claim 14, wherein the Group 3 metal oxide layer is selected from the group consisting of an aluminum oxide layer and a yttrium oxide layer.

16. The method of claim 14, wherein the high dielectric layer further comprises at least one layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

17. The method of claim 14, wherein said nitriding is performed using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment in a nitrogen atmosphere process, and a process comprising forming a nitrogen layer over the high dielectric layer and thermally treating the formed nitrogen layer.

18. The method of claim 14, wherein said annealing the silicon substrate, ozone oxide layer, and high dielectric layer comprises annealing the silicon substrate, ozone oxide layer, and high dielectric layer in an atmosphere selected from the group consisting of an inert gas atmosphere, a heavy hydrogen atmosphere, a hydrogen atmosphere, a mixed nitrogen and hydrogen gas atmosphere, and a vacuum atmosphere.

19. The method of claim 14, wherein said annealing the silicon substrate, ozone oxide layer, and high dielectric layer comprises annealing the silicon substrate, ozone oxide layer, and high dielectric layer at a temperature at or between about 750 °C and 1100 °C.

20. A method for forming a high dielectric layer of a semiconductor device, comprising:

forming an ozone oxide layer over a silicon substrate;

forming a high dielectric layer on said ozone oxide layer, wherein said high dielectric layer comprises at least one layer selected from the group consisting of a hafnium oxide layer, a zirconium oxide layer, and a Group 3 metal oxide layer;

nitriding said silicon substrate and said high dielectric layer on said silicon substrate; and

then oxidizing the silicon substrate and high dielectric layer.

21. The method of claim 20, wherein forming said ozone oxide layer over said silicon substrate comprises flushing said silicon substrate with ozone *in situ*.

22. The method of claim 20, wherein forming said ozone oxide layer over said silicon substrate comprises forming said ozone oxide layer using atom layer deposition.

23. The method of claim 20, wherein forming said ozone oxide layer over said silicon substrate comprises forming said ozone oxide layer using chemical vapor deposition.

24. The method of claim 20, wherein forming said ozone oxide layer over said silicon substrate comprises forming said ozone oxide layer at a temperature between about 320 °C and about 450 °C.

25. The method of claim 20, wherein said ozone oxide layer comprises an ozone oxide layer having a thickness of about 8 Å or less.

26. The method of claim 20, wherein the Group 3 metal oxide layer is selected from the group consisting of an aluminum oxide layer and a yttrium oxide layer.

27. The method of claim 20, wherein the high dielectric layer further comprises at least one layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

28. The method of claim 20, wherein said nitriding is performed using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal

treatment in a nitrogen atmosphere process, and a process comprising forming a nitrogen layer over the high dielectric layer and thermally treating the formed nitrogen layer.

29. The method of claim 20, wherein said oxidizing the silicon substrate and high dielectric layer comprises wet oxidizing the silicon substrate and high dielectric layer.

30. The method of claim 20, wherein said oxidizing the silicon substrate and high dielectric layer comprises dry oxidizing the silicon substrate and high dielectric layer.

31. The method of claim 20, wherein said oxidizing the silicon substrate and high dielectric layer comprises oxidizing the silicon substrate and high dielectric layer with an oxidizing agent selected from the group consisting of ozone, radical oxygen, and oxygen plasma.

32. A method for forming a high dielectric layer of a semiconductor device, comprising:

forming an ozone oxide layer over a silicon substrate;

forming a high dielectric layer on said ozone oxide layer, wherein said high dielectric layer comprises at least one layer selected from the group consisting of a hafnium oxide layer, a zirconium oxide layer, and a Group 3 metal oxide layer;

nitriding a silicon substrate and a high dielectric layer on said silicon substrate;

then oxidizing the silicon substrate and high dielectric layer; and

annealing the nitrided and oxidized silicon substrate and high dielectric layer.

33. The method of claim 32, wherein forming said ozone oxide layer over said silicon substrate comprises forming said ozone oxide layer over said silicon substrate using a method selected from the group consisting of flushing said silicon substrate with ozone *in situ*, using atom layer deposition to form said ozone oxide layer, and using chemical vapor deposition to form said ozone oxide layer.

34. The method of claim 32, wherein forming said ozone oxide layer over said silicon substrate comprises forming said ozone oxide layer at a temperature between about 320 °C and about 450 °C.

35. The method of claim 32, wherein said ozone oxide layer comprises an ozone oxide layer having a thickness of about 8 Å or less.

36. The method of claim 32, wherein the Group 3 metal oxide layer is selected from the group consisting of an aluminum oxide layer and a yttrium oxide layer.

37. The method of claim 32, wherein the high dielectric layer further comprises at least one layer selected from the group consisting of a hafnium silicate layer, a zirconium silicate layer, and an aluminum silicate layer.

38. The method of claim 32, wherein said nitriding is performed using a nitriding process selected from the group consisting of a nitrogen plasma treatment process, a thermal treatment in a nitrogen atmosphere process, and a process comprising forming a nitrogen layer over the high dielectric layer and thermally treating the formed nitrogen layer.

39. The method of claim 32, wherein said oxidizing the silicon substrate and high dielectric layer comprises wet oxidizing the silicon substrate and high dielectric layer.

40. The method of claim 32, wherein said oxidizing the silicon substrate and high dielectric layer comprises dry oxidizing the silicon substrate and high dielectric layer.

41. The method of claim 32, wherein said oxidizing the silicon substrate and high dielectric layer comprises oxidizing the silicon substrate and high dielectric layer with an oxidizing agent selected from the group consisting of ozone, radical oxygen, and oxygen plasma.

42. The method of claim 32, wherein said annealing the nitrided and oxidized silicon substrate and high dielectric layer comprises annealing the nitrided and oxidized silicon substrate

and high dielectric layer in an atmosphere selected from the group consisting of an inert gas atmosphere, a heavy hydrogen atmosphere, a hydrogen atmosphere, a mixed nitrogen and hydrogen gas atmosphere, and a vacuum atmosphere.

43. The method of claim 32, wherein said annealing the nitrided and oxidized silicon substrate and high dielectric layer comprises annealing the nitrided and oxidized silicon substrate and high dielectric layer at a temperature at or between about 750 °C and 1100 °C.

44. The method of claim 32, wherein said oxidizing the silicon substrate and high dielectric layer comprises oxidizing the silicon substrate and high dielectric layer at or between a temperature of about 700 °C to about 900 °C.

45. A method for treating a high dielectric layer of an integrated circuit device, comprising nitriding to provide a nitride profile concentration in the high dielectric layer that is greater adjacent to the polysilicon/high dielectric layer interface than adjacent to a silicon/ozone oxide/high dielectric layer interface.